



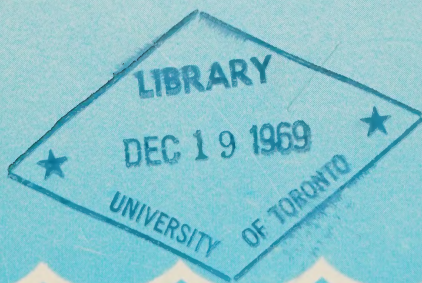
In General publication

CANADIAN DRINKING WATER STANDARDS

AND OBJECTIVES 1968



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A PUBLICATION OF
THE DEPARTMENT OF NATIONAL HEALTH AND WELFARE, CANADA



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CANADIAN DRINKING WATER STANDARDS AND OBJECTIVES 1968

Prepared by
The Joint Committee on Drinking Water Standards
of
The Advisory Committee on Public Health Engineering
and
The Canadian Public Health Association

Published by authority of
THE HONOURABLE JOHN MUNRO
Minister of National Health and Welfare

October 1969

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Catalogue No. H48-1069

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Queen's Printer for Canada
Ottawa, 1969

Foreword

The desirability of having uniform drinking water standards throughout Canada has been recognized for sometime. In response to this need, both the Canadian Public Health Association, and The Department of National Health and Welfare, through its Advisory Committee on Public Health Engineering, independently set in motion studies to develop such standards and subsequently formed a joint committee which has prepared this document.

Criteria designed to protect public health must be based on a meaningful interpretation of present-day knowledge and experience. Constantly changing technology, advances in medical science and a greater understanding of the impact of the environment on man, will combine to make necessary periodic re-assessments of these standards and objectives. This document will, therefore, be reviewed and up-dated as circumstances demand.

In recommending these standards and objectives to the community at large, it is hoped that by incorporating graded scales and providing detailed explanations, responsible authorities will be able to apply them with understanding, judgment and discretion.

JOHN MUNRO
Minister
Department of National
Health & Welfare.

Foreword

The objectives of the Canadian Public Health Association include the development and distribution throughout Canada of knowledge of public health and preventive medicine. The quality of water supplied for human consumption is a matter of increasing importance to public health agencies. The sources of water which provide the raw water input to our treatment plants are exposed to heavier pollution and to new pollutants as population densities increase and technical and industrial developments advance.

At the same time, new methods are being developed for treating drinking water, protecting it in the distribution system, processing waste water effluents, and maintaining surveillance systems for both raw and finished waters.

The Canadian Public Health Association has been pleased to collaborate with the Department of National Health and Welfare in the establishment of a joint committee for the purpose of developing these standards for drinking water. The Association recommends the standards and objectives set out in this document to all concerned with the quality of drinking water.

C. B. STEWART, M.D.

President

*Canadian Public Health
Association.*

Acknowledgement

The investigation and publication of the Canadian Drinking Water Standards and Objectives were made possible by the generous technical and financial support of the Public Health Engineering Division of the Department of National Health and Welfare. The Joint Committee on Drinking Water Standards acknowledges in particular the enthusiasm and support of the late Mr. W. R. Edmonds, Chief, Public Health Engineering Division, Department of National Health and Welfare, who was largely responsible for establishing co-ordination between the CPHA Drinking Water Standards Committee and the Sub-Committee on Drinking Water Standards of the Department's Advisory Committee on Public Health Engineering.

Many experts and private consultants offered constructive criticisms and helpful suggestions, but the list is too long for individual acknowledgement. The committee, however, expresses deep appreciation and thanks to all reviewers and consultants. Advice and useful comments were also made by a number of United States experts, including: Dr. Harold W. Wolf, Chief, Division of Criteria and Standards, Bureau of Water Hygiene, Environmental Control Administration, U.S. Public Health Service; Dr. Gerald Berg, Chief, Virus Disease Studies, Dr. Shih L. Chang, Chief, Water Treatment Evaluation Studies, and Dr. Edwin E. Geldreich, Chief, Bacterial Studies Unit, all of the Robert A. Taft Sanitary Engineering Centre, U.S. Federal Water Pollution Control Administration.

Report of the Joint Committee on Drinking Water Standards

A brief history of drinking water standards in Canada might begin with an Order-in-Council of the Federal cabinet, approved June 19, 1923¹, which provided a standard of bacteriological quality applicable to water used for drinking and culinary purposes on vessels, navigating on the Great Lakes and Inland Waters. In 1930², an Order-in-Council applied similar standards to all types of common carriers crossing Canadian interprovincial or international borders and, in 1937³, Canadian coastal shipping was included.

In 1951, and again in 1955, the predecessor of the present Advisory Committee on Public Health Engineering considered the need for drinking water standards and there is reference in the 1955 minutes to a Water Quality Standard Committee under the Charimanship of the late Mr. J. R. Menzies^{4, 5}. At its 48th meeting, the Dominion Council of Health approved the application of the 1943 United States Public Health Service Drinking Water Standards by the Department of National Health and Welfare, pending examination of the situation and development of Canadian Standards. United States Drinking Water Standards were issued in 1914, 1925, 1942, 1946 and 1962, and World Health Organization Standards in 1958, (International), 1961 (European), 1963 (International). These standards are frequently referred to by Canadian authorities.

The Canadian Public Health Association established its Drinking Water Standards Committee in recognition of a need in Canada for a statement by public health authorities of drinking water quality standards and objectives which would be applicable to the wide range of characteristics of the available raw water supplies in different parts of our country.

At its first meeting in January 1966, the committee defined as its objective the development of guidelines for use of Canadian public health and public water utility personnel in the surveillance and provision of safe drinking water supplies for both public and private use. The committee recognized the impor-

¹ Order-in-Council, P.C. 1091, June 19, 1923.

² Order-in-Council, P.C. 417, February 25, 1930.

³ Order-in-Council, P.C. 475, March 9, 1937.

⁴ Advisory Committee on Public Health Engineering, Minutes of Second Meeting, February 8, 1951.

⁵ Advisory Committee on Public Health Engineering, Minutes of Sixth Meeting, March 21-23, 1955.

tance of establishing a means of communicating to the waterworks industry the concerns of public health officials relating to water supply quality, and it was hoped that the production of guidelines would meet this need.

In January 1967, the Department of National Health and Welfare convened an Advisory Committee on Public Health Engineering, with membership representative of the Federal and Provincial Departments of Health, several of the universities, and the Canadian water pollution and water resource control agencies. At its initial meeting the Advisory Committee set up a Sub-Committee on Drinking Water Standards to develop and promote national criteria, standards, and objectives for drinking water.

With overlapping membership between this committee and the C.P.H.A. Drinking Water Standards Committee, it was agreed that the two committees should combine their efforts and work as a single joint committee. This arrangement for collaboration was subsequently approved on behalf of C.P.H.A. by its Research Committee.

Experience had already indicated the need for the services of a full-time investigator and, on the advice of its Advisory Committee, the Department of National Health and Welfare appointed Mr. S. K. Krishnaswami, a well qualified officer experienced in the evaluation of drinking water criteria, to serve the joint committee as Principal Investigator on a full-time basis. In the ensuing period this officer in consultation with the members of the committee and numerous other specialists and agencies has produced two preliminary reports, an interim report, and several drafts of the standards now in your hands.

In presenting these standards to you the joint committee adopts the philosophy that water for drinking, culinary and other domestic uses, should be free from pathogenic organisms and their indicators and from deleterious chemical substances and radioactive materials, and it should also be palatable, aesthetically appealing and devoid of objectionable colour, odour, and taste. The committee recognizes that other considerations such as corrosiveness, a tendency to form incrustations, or excessive soap consumption due to hardness are important aspects of drinking water quality in terms of consumer acceptance.

The committee considers it desirable to recommend three levels of quality. The poorest of these quality levels is designated as "maximum permissible", the next "acceptable" and the best "objective". Water of a quality that would meet the "objective" for each characteristic should be the long-range goal, but it is emphasized that the specification of "maximum permissible" limits should not be interpreted as a permit to allow the degradation of drinking water to the indicated levels. Drinking water must not be permitted to carry continuously any of the materials at the specified maximum permissible concentrations.

The committee established the following guidelines:

1. The proposed standards should take into consideration existing drinking water standards, such as the World Health Organization International and European Drinking Water Standards (1963 and 1961) and the U.S. Public Health Service Drinking Water Standards (1962).
2. Scientific information related to water quality published since 1962 should be reviewed.
3. Drinking water quality objectives for long-range planning and control should be included under "objectives"; the minimum and immediate

requirements for attaining safe and acceptable drinking water quality should be specified as "acceptable" limits and where scientific information justifies a need to propose "maximum" limits, such limits should be clearly indicated as not only the "maximum permissible limits" but also as sufficient grounds for the rejection of a water supply when such limits are exceeded.

4. The term "standard" should be applied to a specified limit for a substance only if there has been a demonstrated relationship of the substance to human health by toxicity, disease, or possible cumulative dosage to a hazardous level.
5. In all cases, a brief statement of the criteria used for arriving at specific limits should be included in the text.
6. The proposed Standards and Objectives should be discussed widely and due cognizance should be given to regional or local problems of water quality management.
7. The Proposed Standards and Objectives should be applicable to all drinking water, private or public.
8. The proposed Standards and objectives should be reviewed periodically in the light of any new scientific information that may become available.
9. In view of the severity of health effects of biocide pollution, tentative standards for some of the commonly used biocides should be specified.
10. Limits on fluoride concentration, where fluoridation of drinking water is instituted, should be included.
11. The possibility of enteroviral transmission through drinking water should be recognized; the viral hazard should be briefly discussed and attention should be drawn to the incompleteness of available knowledge for specifying a quantitative limit on viral concentration.
12. For radioactive substances, the recommendations of the International Commission on Radiological Protection should form the basis of standards, and the standards should take into consideration continuous exposure to radioactive substances assuming that water is the only contributing source.

In developing the Standards and Objectives, the Committee took cognizance of the changing environmental conditions in Canada, their effect on drinking water supplies, the economic problems of treatment, sampling, and analysis of smaller water supplies, and the lack of judicious criteria, in some cases, for developing precise concentration limits.

The recommendations contained herein are based upon the most reasonable criteria and the best scientific information available at present. These criteria are presented briefly in Section 8. The Committee urges that the criteria presented in Section 8 be used with understanding, judgment, and discretion. It is also important that these criteria be applied as a guide in the control of pollution of raw water sources serving drinking water supplies, and, where there is a conflict between these criteria and other considerations the most sensitive criteria should apply.

The Committee recommends that a system of drinking water surveillance be established for assessing the significance to health, aesthetics, and economics of possible changes in water quality that may be brought about by the accelerating pace of new developments in the industrial-urban environment in Canada.

It is further recommended that federal, provincial, academic, and industrial agencies in Canada undertake studies, on a continuing basis, toward the development of basic information on the relationship of biological, chemical, physical, and radiological characteristics of water to public health.

The following pages contain the Canadian Drinking Water Standards and Objectives — 1968 recommended by this Joint Committee, the membership of which is listed in Appendix II.

W. M. WALKINSHAW, M.A.Sc., P.ENG.,
Chairman,
Joint Committee on Drinking Water
Standards.

March 5, 1969.

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Canadian Drinking Water Standards and Objectives

*1968**

The following quality standards and objectives for drinking water in Canada are recommended by the Division of Public Health Engineering, Department of National Health and Welfare, Government of Canada, and the Canadian Public Health Association. These recommendations apply to all public, private or individual drinking water supplies. In their application, it is intended that, where doubts arise regarding interpretation, the operator shall be guided by the interpretation of the appropriate health or water control agency.

1. Introduction

Water for drinking, culinary, or other domestic uses should be safe, palatable, and aesthetically appealing. It should be free from pathogenic organisms, deleterious chemical and radioactive substances, and objectionable colour, odour, and taste. Other considerations, such as corrosiveness, tendency to form incrustations, and excessive soap consumption due to hardness should also be regarded as important in evaluating the quality of drinking water.

Drinking water should be adequately protected from pollution due to chemical and radioactive substances, and pathogenic organisms, by natural processes or by water treatment processes in order to ensure safety and consistency in quality. The location and design of water treatment and distribution system components (including reservoirs) should be such as to prevent contamination.

The following *standards* and *objectives* are recommended in order to ensure that drinking water supplies will have the aforementioned quality characteristics.

2. Types of Limits

Three types of limits are proposed, namely *objective*, *acceptable*, and *maximum permissible*, for the following reasons:

- 2.1 **Objective:** These limits should be interpreted as the long-term quality goal to be reached. It is implied that water supplies, which meet these requirements, are of very good and safe quality from health, aesthetic, and other viewpoints.

*Appendix I provides definitions of terms used in this document.

- 2.2 **Acceptable Limits:** These limits should not be exceeded whenever more suitable supplies are, or can be made, available within the technological and economic resources of the community. Substances in this category, when present in concentrations above the indicated limits, are either objectionable to a significant number of people or capable of producing deleterious health or other effects. When periodic evaluations of the quality confirm that the water as supplied falls between the *objective* and *acceptable* limits, a more frequent and comprehensive surveillance programme should be instituted. Any water supply, when exceeding the *acceptable* limits in one or more of the quality characteristics, should be assessed on its individual merits as to its suitability and safety from health, aesthetic, and other viewpoints.
- 2.3 **Maximum Permissible Limits:** These limits are *standards*. The term *standard* is used for limits on certain substances that are known or suspected to be linked with human health (e.g. toxic chemicals, radioactive substances, pathogenic organisms). The limits, in each case, if exceeded, shall be sufficient grounds for the rejection of the water supply unless effective remedial treatment is applied to either totally remove the particular substance or to bring it to a concentration below the tabulated limit. Substances in this category, when present in concentrations above the indicated values, have been associated with adverse effects on human health. Lesser concentrations, therefore, are desirable and no water supply should be permitted to carry these chemicals at the indicated levels continuously. When the quality falls between the *acceptable* and *maximum permissible* limits, careful surveillance must be maintained with active considerations of what steps would be taken when the *maximum permissible* limits are exceeded.
- 2.4 The practical use of these types of limits is closely associated with the need for sampling frequency and possible corrective action. These limits are recommended on the basis of currently available information, and are subject to revision or adjustment as new and more significant data become available. In the majority of the cases, factors of safety, and Canadian conditions of the environment, have been taken into consideration in recommending these limits.

3. Sources of Water Supplies

There is a relationship between the quality of the *raw* water and the treated water used for a drinking water supply. Some quality parameters are not affected by currently practised or available water treatment processes; others are affected to a limited degree and still others can be controlled by treatment. Where *complete* treatment processes are used,

colour, odour, taste, turbidity, and microorganisms can be effectively reduced to an acceptable level. Where chlorination is the only treatment applied, the finished water will have almost the same quality as that of the source, except in microbiological and, to a lesser extent, colour, odour, and taste characteristics.

Modern water treatment technology is capable of producing a finished water meeting these standards even from a heavily polluted *raw* water. The cost of treatment and possible deficiencies in operating procedures, however, will determine the quality of the finished water. It is essential, therefore, that the water supply should be obtained from a source that can be treated by the applied processes and operating procedures to produce drinking water meeting the quality recommended herein. When water supplies are derived from polluted sources, effective treatment must be provided to ensure safety and consistency in the quality of the finished water.

A sanitary survey should be conducted within the drainage area periodically to locate and identify potential health hazards which may affect the system. Suitable and effective corrective action to prevent, control, and eliminate the causes of any recognized hazards must be instituted at the earliest possible time.

4. *Physical Characteristics*

- 4.1 **Sampling:** Under normal circumstances, samples should be collected at least once per week from the *raw* water intake, the treated water, and at least seasonally from representative points in the distribution system, for the determination of the physical quality.

TABLE I
PHYSICAL QUALITY OF TREATED WATER¹

Parameter ²	Objective	Acceptable Limit
Colour — TCU ³	<5	15
Odour — T.O.N. ⁴	0	4
Taste	Inoffensive	Inoffensive
Turbidity — JTU ⁵	<1	5
Temperature — °C	<10	15
pH — Units ⁶	—	6.5 — 8.3

¹ See Section 8.1.

² To be examined according to the latest edition of Standard Methods for the Examination of Water and Wastewater (American Public Health Association, American Water Works Association, and Water Pollution Control Federation), or other acceptable methods as approved by the control agency.

³ True Colour Unit, Platinum-Cobalt Scale.

⁴ Threshold Odour Number.

⁵ Jackson Turbidity Unit.

⁶ Has significance in controlling corrosion and scaling tendency of the water (See Section 8.1.5).

Where problems of turbidity, odour and taste occur, the assistance of the control agency may be necessary for determining the frequency of sampling. When the quantitative values of these characteristics exceed the *acceptable* limits tabulated below, special series of samples should be examined, and suitable corrective action should be taken to bring the levels below the *acceptable* limits. The frequency and manner of special sampling shall be determined by the control agency.

- 4.2 **Limits:** These limits should be obtained generally at the consumer's tap with the possible exception of the limit on temperature (see Table 1).

5. *Microbiological Characteristics*

5.1 **Nuisance Organisms:**

5.1.1 **Sampling:** The frequency of sampling and analysis for non-pathogenic organisms (other than organisms indicative of enteric pollution), and nuisance organisms which may cause various objectionable conditions in the water supply system (See Section 8.2 and 8.2.1) shall be determined by the control agency based on considerations of the likelihood of significant kinds and concentrations of such organisms being present.

5.1.2 **Limit:** Biological organisms in concentrations which may produce objectionable colour, taste, odour and turbidity, or which may adversely interfere with water treatment processes and operations, or which may release toxic metabolites, are undesirable in drinking water. These organisms must be kept below such concentrations as to prevent the aforementioned undesirable effects.

5.2 **Pathogenic Organisms:**

5.2.1 **Sampling:** Under normal circumstances, the need and frequency of sampling and examination for pathogenic organisms shall be determined by the Medical Officer of Health or the control agency based on considerations of the nature of the water supply source, degree of pollution, the effectiveness of applied water treatment processes, and other factors (See Section 5.3).

5.2.2 **Limit:** The demonstration of the presence of any pathogenic organism in drinking water must constitute ground for the rejection of the water supply unless effective remedial treatment and disinfection are applied immediately. Alternatively, where conditions of hazards due to the presence of pathogenic organisms exist, the Medical Officer of Health or the control agency may authorize the

issuance of an order requiring boiling of the water before consumption or other corrective action.

- 5.3 **Coliform Organisms:** Standards for the microbiological quality of drinking water are essential for the protection of the public from waterborne infections and diseases caused by microbial agents. It is recognized that, despite certain recent developments in the culturing, identification, and enumeration of pathogenic bacteria, viruses, and faecal coliforms, occurring in water, the evaluation of the microbiological quality of drinking water by the total coliform method is still valid, relatively rapid, and reliable.

Both the multiple-tube fermentation (Most Probable Number or MPN) technique and the membrane filter (MF) technique are now accepted as standard, reliable methods for the enumeration of coliform bacteria in water. It has been established, however, that the two tests do not measure precisely the same coliform spectra, and that, for some waters, the membrane filter technique produces a somewhat lower coliform density estimate than the MPN technique. It is therefore recommended that the membrane filter coliform test be used for determining the potability of a given water supply only after adequate parallel testing has demonstrated that it yields equivalent information, relative to the sanitary quality of the water supply system, to that given by the multiple tube MPN procedure. It is recommended that a statistically significant proportion of "coliform-positive" samples be subjected to completed test procedures in order to ensure that the isolated organisms are coliforms.

The procedures used in the routine examination of drinking water for coliform bacteria shall be those set forth in **Standard Methods for the Examination of Water and Wastewater**, current edition, prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

The microbiological and other relevant conditions at the source of the supply, and throughout the distribution system, should be investigated periodically by sanitary inspection. If such inspection indicates the water, as distributed, to be subject to pollution, the water should be considered as of questionable quality irrespective of the results of bacteriological examinations of the finished water leaving the water treatment plant. In this case, a special series of samples, over a significant period of time, should be examined for total coliform, faecal coliforms, and, if possible, viruses, salmonellae and Standard Plate Counts (20° and 35°C).

- 5.3.1 **Sampling:** Compliance with the bacteriological requirements of the standards and objectives shall be based on the examination of water samples collected at a series of

MINIMUM NUMBER OF SAMPLES PER MONTH

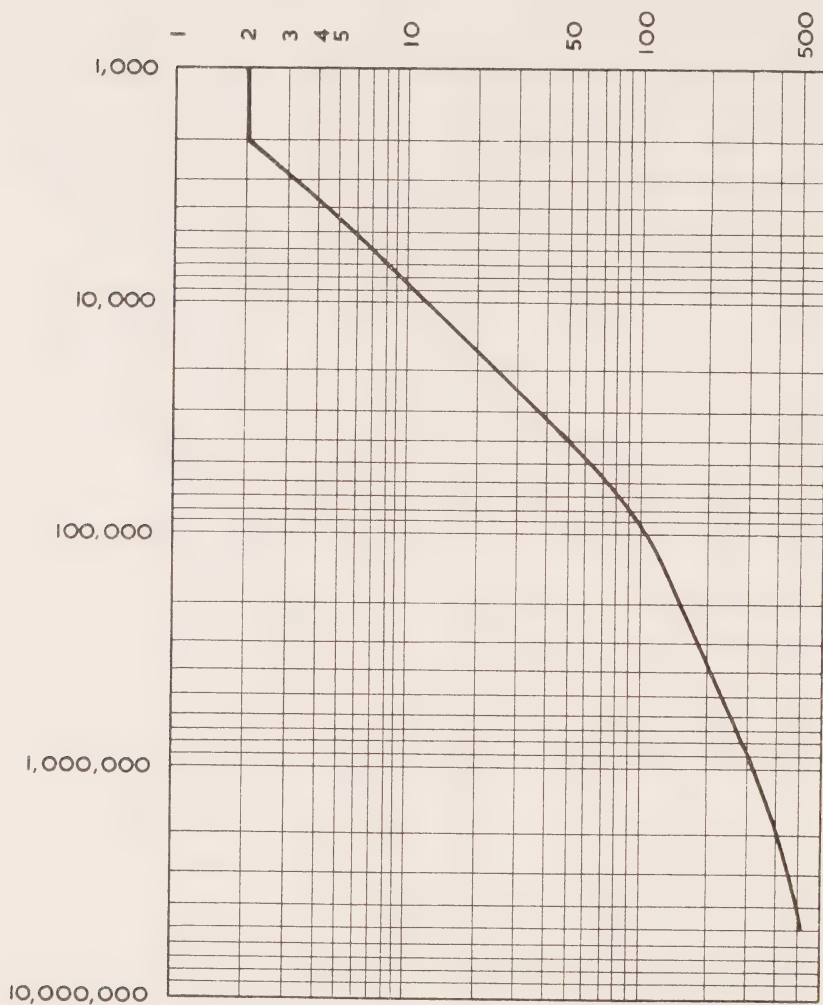


Figure 1

BACTERIOLOGICAL SAMPLING FREQUENCY

Adopted from the U.S. Public Health Service Drinking Water Standards — 1962.

Guide Rule—For the population range 2,000 – 100,000, a guide rule of 1.2 samples per 1,000 population per month may be used, but the minimum number of samples is 2 per month for population up to 2,000.

representative points throughout the distribution system. The frequency of sampling and the location of sampling points shall be established by the control agency or the Medical Officer of Health after a complete investigation of the source and the method of treatment and protection of the water supply. The number of samples to be subjected to test shall be increased in accordance with the size of the population served by the system as shown in Figure 1.

- 5.3.2 **Disinfection and Chlorine Residual:** Daily tests for concentrations of chlorine residuals in the treated water after the required contact time must be performed regardless of the frequency of bacteriological sampling. The frequency of tests for concentrations of chlorine residuals in water collected from representative points in the distribution system shall be determined by the control agency.

It is recommended that at all times public water supplies carry a measurable residual of *free* chlorine (i.e. $\text{HOCl} + \text{OCl}^-$) which is detectable at any point in the system. It is desirable that the concentration of *free* chlorine residual in the treated water be at a level not less than 0.5 mg/l, after a minimum contact time of 20 minutes. However, where *free* chlorine residual leads to objectionable taste and odour, the control agency or the Medical Officer of Health shall determine the type and concentration of chlorine residual and the contact time required to produce a microbiologically safe water.

It is further recommended that all individual and private drinking water derived from surface sources or shallow wells be disinfected in accordance with the advice of the Medical Officer of Health. In the absence of erratic or high level coliform contamination, the Medical Officer of Health may advise that the disinfection of water derived from private wells may not be necessary.

- 5.3.3 **Limits: Total Coliform Most Probable Number (MPN):** The limits on total coliform organisms, enumerated by the Most Probable Number multiple tube fermentation method, are presented in Table II. These limits should be interpreted as *standards* applicable to the treated water.

Waters which produce an MPN index of 4 to 10 per 100 ml in more than three consecutive examinations should be immediately investigated, and a special series of samples should be collected from the source, at the treatment plant, and from several representative locations in the distribution system.

TABLE II
TOTAL COLIFORM STANDARDS FOR
DRINKING WATER
(MPN METHOD)*

<i>Objective</i>	<i>Acceptable Limit</i>	<i>Maximum Permissible Limit</i>
(a) No coliforms	At least 95% of the samples in any consecutive 30-day period should be "negative" for total coliform organisms.	At least 90% of the samples in any consecutive 30-day period should be "negative" for total coliform organisms.
(b) No coliforms	None of the samples "positive" for total coliform organisms should have an MPN index greater than 4 per 100 ml.	None of the samples "positive" for total coliform organisms should have an MPN index greater than 10 per 100 ml.

*Where less than 10 samples are analyzed in any consecutive 30-day period, *no more than one* sample should be "positive" for total coliform organisms. When more than *one* "positive" sample is encountered, a special series of samples should be collected from the same location and analyzed for total coliform organisms.

It is recommended that, if other combinations of dilutions are used in routine tests, a statistically significant number of samples, in any consecutive 30-day period, be subjected to the Standard Fifteen Tube Multiple Dilution (MPN) Test.

5.3.4 Limits: Total Coliform Count by the Membrane Filter Method: The limits for total coliform organisms, enumerated by the Membrane Filter Method, are presented in Table III. These limits should be interpreted as *standards* applicable to the treated water.

It is recommended that a *minimum* sample volume of 200 ml be subjected to the membrane filter test for coliform bacteria. Waters which produce a coliform count, by the membrane filter test, of 6 per 200 ml or 15 per 500 ml portions, or which approach these limits, in more than three consecutive samples should be immediately investigated and the identity of the organisms isolated should be verified by the completed test procedures. A special series of samples should be collected from the source, at the treatment plant, and from several representative locations in the distribution system.

TABLE III
TOTAL COLIFORM STANDARDS FOR
DRINKING WATER
(MF METHOD)*

<i>Objective</i>	<i>Acceptable Limit</i>	<i>Maximum Permissible Limit</i>
(a) No coliforms	At least 95% of the samples in any consecutive 30-day period should be "negative" for total coliform organisms.	At least 90% of the samples in any consecutive 30-day period should be "negative" for total coliform organisms.
(b) No coliforms	None of the samples "positive" for total coliform organisms should have a MF Count greater than 4 per 200 ml or 10 per 500 ml portions.	None of the samples "positive" for total coliform organisms should have an MF Count greater than 6 per 200 ml or 15 per 500 ml portions.

*Where less than 10 samples are analyzed in any consecutive 30-day period, *no more than one* sample should be "positive" for total coliform organisms. When more than *one* "positive" sample is encountered, a special series of samples should be collected from the same location and analyzed for total coliform organisms.

5.3.5 Any deviations from these MPN and MF standards must result in the immediate collection of a special series of samples from the water supply system, and the commencement of suitable and effective remedial measures to ensure the microbiological safety of the water supplied to the community. When deviations from these standards occur, all samples must be carried to the "completed" test procedures.

5.3.6 **Faecal Coliforms in Raw Water:** The entry of faecal discharges into water may add a variety of enteric pathogenic organisms, at any time. The pathogenic organisms (e.g. *Salmonella*, *Shigella*, *Vibrio*, *Mycobacterium*, *Pasteurella*, *Leptospira*) are likely to be present, at one time or another, in raw water. Although recent qualitative and quantitative studies on certain pathogenic organisms have produced promising techniques, these methods do not render themselves, at present, to routine application from technical and economic viewpoints. Besides, the use of these organisms as the sole indicators of enteric pollution is not desirable at the present time because the intervals between

sampling, detection, and corrective action on a water supply result in certain exposure risks to the consumer; also, a failure to demonstrate the presence of pathogenic organisms does not necessarily ensure microbiological safety of a water supply.

Recent qualitative and quantitative studies to distinguish between faecal and non-faecal coliform bacteria have yielded certain procedures that can be successfully and routinely employed to evaluate the bacterial quality of water. The quantitative relationship between faecal coliforms on the one hand, and total coliforms and enteropathogenic bacteria on the other, will vary from source to source, and, within the same source, from time to time. It is recognized, nevertheless, that the faecal coliform test has additional value in assessing the microbial quality of water, particularly *raw* water that is subject to pollution by enteric wastes.

TABLE IV
RAW WATER FAECAL COLIFORM STANDARDS*

<i>Objective</i>	<i>Acceptable Limit</i>	<i>Maximum Permissible Limit</i>
At least 95% of the samples in any consecutive 30-day period should have a faecal coliform density of less than 10 per 100 ml.	At least 90% of the samples in any consecutive 30-day period should have a faecal coliform density of less than 100 per 100 ml.	At least 90% of the samples in any consecutive 30-day period should have a faecal coliform density of less than 1,000 per 100 ml.
Treatment by chlorination is required (See Section 5.3.10).	Complete or partial treatment including chlorination may be required. (See Section 5.3.10).	Complete water treatment is required. (See Section 5.3.10).

*The *Maximum Permissible Limit* of faecal coliforms in a single sample shall be determined by the control agency based upon considerations of the type and degree of enteric pollution and other local conditions within the watershed.

It is recommended, therefore, that enterically polluted *raw* water sources, when used for public supplies, be examined periodically for faecal coliform content. Since conditions of enteric pollution will vary in time and geographic location, it is difficult to specify the number of samples and frequency of testing for faecal coliforms; these shall, therefore, be determined by the control agency.

- 5.3.7 **Limits for Faecal Coliforms:** Limits for faecal coliforms, applicable to the *raw* water sources of drinking water supplies, are recommended as presented in Table IV. These limits apply regardless of whether the MPN or the MF methods are used.
- 5.3.8 **Total Coliforms in Raw Water:** Notwithstanding the standards for faecal coliforms recommended in Section 5.3.7, limits for total coliforms, as applied to the *raw* water source, are recommended as presented in Table V. It is pointed out that the standards for faecal and total coliforms tabulated in Tables IV and V do not necessarily reflect such quantitative correlation between the organisms.
- 5.3.9 **Limits for Total Coliforms:** The limits recommended in Table V apply regardless of whether the MPN or MF procedures are used, and are applicable to the *raw* water source.
- 5.3.10 The limits tabulated under the *acceptable* and *maximum permissible* column, in Tables IV and V, apply only where

TABLE V
RAW WATER TOTAL COLIFORM STANDARDS*

<i>Objective</i>	<i>Acceptable Limit</i>	<i>Maximum Permissible Limit**</i>
At least 95% of the samples in any consecutive 30-day period should have a total coliform density of less than 100 per 100 ml.	At least 90% of the samples in any consecutive 30-day period should have a total coliform density of less than 1,000 per 100 ml.	At least 90% of the samples in any consecutive 30-day period should have a total coliform density of less than 5,000 per 100 ml.
Treatment by chlorination is required. (See Section 5.3.10).	Complete or partial treatment including chlorination is required. (See Section 5.3.10).	Complete water treatment is required. (See Section 5.3.10).

*The *Maximum Permissible Limit* of total coliform organisms in a single sample shall be determined by the control agency based on the type and degree of pollution and other local conditions existing within the watershed.

** (1) Applicable to the *raw* water *only* where complete treatment (as defined in the Glossary) of drinking water is employed. (2) Where 5,000 total coliforms per 100 ml are found in more than 10% of the samples examined during the survey period, auxiliary treatment consisting of pre-chlorination or pre-sedimentation or their equivalents, and post-chlorination shall be applied. (3) In all other cases, the limits tabulated under *objective* shall apply.

complete treatment [flocculation-coagulation, sedimentation, filtration, and disinfection, or any combination of these processes (partial treatment), but always including

disinfection] is employed for public supplies; where only disinfection is employed, the limits tabulated under the *objective* column apply.

When these limits are exceeded, an immediate investigation of the origin and nature of pollution of the source must be undertaken. A special series of samples should be collected and examined for the bacteriological, and, possibly, also virological quality of the source. It is also important that concurrent samples of the treated water, from the plant and from several representative locations in the distribution system, should be examined for total coliform content in order to ensure the microbiological safety of the water.

- 5.4 **Viruses:** The entry of faecal discharges through wastewaters into raw water sources may add a variety of pathogenic and non-pathogenic organisms of enteric origin. Water contaminated by faecal wastes may also contain members of the group of viruses designated as *enteroviruses* (echoviruses, polioviruses, and coxsackieviruses—Groups A and B). Adenoviruses, reoviruses, and the virus(es) of infectious hepatitis also may be present in faecal discharges. The possibility exists that any of these viruses will occur in sewage-contaminated water. There is, however, no obvious widespread dissemination in Canada of viral diseases through drinking water supplies controlled by existing criteria of microbial safety. Under certain circumstances, pathogenic viruses may survive water treatment and disinfection conditions which eliminate coliform bacteria and other organisms.

The main concern today is with the *potential* of drinking water serving as a vehicle for the transmission of viral diseases, particularly when enterically polluted sources are used or when inadequacies in water treatment are evident.

Viruses are not members of the normal intestinal flora in warm-blooded animals including man. Viruses are discharged with the faeces of infected individuals only. The morbidity of virus infections show geographical and seasonal variations. The number of viral units excreted with faecal wastes is usually several orders of magnitude lower than that of coliform organisms. Furthermore, the concentration of viral units is reduced by sewage treatment, dilution in receiving waters, natural die-off, and water treatment. The possibility of transmission of viruses through drinking water, therefore, depends fundamentally upon the presence of a minimal infectious dose and its ability to produce infection.

It is not possible, in the present state of our knowledge, to specify (a) a quantitative limit on viruses, (b) frequency of viral assays, and (c) routine methods of viral detection, identification, and quantification. These shall, therefore, be determined by the

Medical Officer of Health or the control agency taking into consideration the microbiological history of the water supply system, the nature and degree of enteric pollution, the effectiveness of water treatment, the epidemiological state of viral diseases in the community, and other factors.

The “gauze-pad” and the “monolayer kidney cell culture” techniques are being used successfully in the qualitative detection of viruses in water; the “membrane filter” method is being used for the quantitative assay of viruses. Where, in the judgment of the Medical Officer of Health or the control agency, viral assay of water is warranted, virologists should be consulted regarding assay procedures. If the presence of any virus is demonstrated in a water supply, emergency action must be taken for the elimination of the virus or the water must be rejected (see Section 5.2).

6. Chemical Characteristics

- 6.1 **Sampling:** Under normal circumstances, sampling for analyses of chemical substances in water need be made only semi-annually. The semi-annual examination should, however, include analyses for all of the substances and characteristics listed below. Where experience, analytical data, and other available evidence indicate that particular substances are consistently absent from a water supply system, or are below the *objective* limits, the frequency of examination for these substances may be reduced, **subject to approval by the control agency.**

If there is sufficient reason to suspect the natural presence or artificial introduction of undesirable or deleterious elements, compounds, or materials, periodic determinations for the suspected toxicant or material should be made more frequently to ensure that the concentration levels are below the *acceptable* limits specified below. Also, a comprehensive sanitary survey should be made to determine the source of pollution, and suitable corrective action should be taken.

Where public supplies are derived from frequently polluted raw sources, the sampling frequency for chemical analyses should be increased to once every three months or as determined by the control agency, and each sample should be analyzed for the suspected toxicant and other deleterious substances.

Where the concentration of a substance is not expected to increase in processing and distribution, analytical data of the *raw* water source, obtained in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater, or other acceptable methods as approved by the control agency, may be used as evidence of compliance with the *standards* and *objectives* recommended in this document.

Where seasonal influences on the chemical quality of the *raw* water sources are expected or known to result in significant changes, the sampling and analytical frequency should be such that these changes are reflected in the analytical data.

It is recognized that the burden of analyses may be alleviated in many cases by using *raw* water data from acceptable governmental sources, or other control agencies. The possibility of contamination from a source internal to the system, however, must not be disregarded.

6.2 Limits: Limits for various chemicals are recommended for drinking water as supplied to the consumer and are presented in Tables VI, VII, and VIII. These limits also apply to the chemicals, in the *raw* water, that are not affected to any significant extent by the applied water treatment processes and operations.

6.2.1 Toxic Chemicals: The limits listed in Table VI should be regarded as *standards*. Concentrations of chemicals higher than the tabulated *maximum permissible limits* should not be permitted in the treated water. Appropriate emergency procedures must be instituted when impermissible concentrations are encountered.

6.3 Biocides

6.3.1 Sampling: In view of the severity of health effects due to

TABLE VI
DRINKING WATER STANDARDS FOR
TOXIC CHEMICALS*

Toxicant	<i>Objective</i> mg/1	<i>Acceptable</i> <i>Limit</i> —mg/1	<i>Maximum</i> <i>Permissible</i> <i>Limit</i> —mg/1
Arsenic as As	Not Detectable ¹	0.01	0.05
Barium as Ba	Not Detectable	<1.0	1.0
Boron as B	—	<5.0	5.0
Cadmium as Cd	Not Detectable	<0.01	0.01
Chromium as Cr ⁺⁶	Not Detectable	<0.05	0.05
Cyanide as CN	Not Detectable	0.01	0.20
Lead as Pb	Not Detectable	<0.05	0.05
Nitrate+Nitrite as N	<10.0	<10.0	10.0
Selenium as Se	Not Detectable	<0.01	0.01
Silver as Ag	—	—	0.05

*See Table VII and Table VIII for limits on biocides and other chemicals.

¹ Not detachable by the method described in the latest edition of "Standard Methods" (APHA, AWWA, & WPCF), or by any other acceptable method approved by the control agency.

biocide pollution of water supply sources, 24-hour composite samples of the *raw* water source and the treated water as supplied to the community should be collected **at least** once every three months. Under normal circumstances, analyses of such samples need be made only for the type of biocides that may be in use within the watershed area. If experience, analytical data, and knowledge of biocide pollution in the drainage area indicate the possible presence of hazardous levels in the *raw* water source, more frequent sampling and analyses should be instituted, as recommended by the control agency. If experience and previous analytical data indicate that hazards due to biocides do not generally exist in the *raw* water source or the drainage area, the frequency of sampling and analyses may be reduced to either annual examination or as approved by the control agency.

6.3.2 **Limits:** The limits listed in Table VII should be regarded as *tentative standards*. These limits are applicable to the

TABLE VII
RAW AND DRINKING WATER STANDARDS
FOR BIOCIDES

Biocide*	Objective and Acceptable Limits	Max. Permissible Limits — mg/1
Aldrin	Not Detectable**	0.017
Chlordane	Not Detectable	0.003
DDT	Not Detectable	0.042
Dieldrin	Not Detectable	0.017
Endrin	Not Detectable	0.001
Heptachlor	Not Detectable	0.018
Heptachlor Epoxide	Not Detectable	0.018
Lindane	Not Detectable	0.056
Methoxychlor	Not Detectable	0.035
Organic Phosphates + Carbamates***	Not Detectable	0.100
Toxaphene	Not Detectable	0.005
Herbicides (e.g. 2,4-D, 2,4,5-T, 2,4,5-TP)	Not Detectable	0.100

*Conventional water treatment has little effect on these dissolved biocides.

**Not detectable by an acceptable method of analysis as approved by the control agency.

***Expressed as parathion equivalents in cholinesterase inhibition.

NOTE: Maximum Permissible Limits are adopted from the Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, U.S. Department of the Interior, 1968. These limits are to be regarded as *tentative standards* since they are still being evaluated.

raw water source as well as the treated water as supplied to the community.

- 6.4 **Fluoride:** If fluoridation is administered for a water supply, the concentration of the fluoride ion (including naturally present fluoride, if any) should be maintained at the optimum level of 1.2 mg/l in the treated water as supplied to the community in all areas of Canada except the arctic and sub-arctic zones. It is recommended that the optimum concentration of fluoride ion in arctic and sub-arctic water supplies be maintained at 1.4 mg/l. The operating range of fluoridation should be within ± 0.2 mg/l at all times. Every effort must be made to maintain the fluoride ion

TABLE VIII
RECOMMENDED LIMITS FOR
OTHER CHEMICALS IN DRINKING WATER

Chemical	Limit — mg/l	
	Objective	Acceptable
Alkalinity	(See Section 8.3.2(1))	
Ammonia as N	0.01	0.5
Calcium as Ca	<75	200
Chloride as Cl	<250	250
Copper as Cu	<0.01	1.0
Corrosion and Incrustation	(See Section 8.3.2(3))	
Iron (dissolved) as Fe	<0.05	0.3
Magnesium as Mg	<50	150
Manganese as Mn	<0.01	0.05
Methylene Blue Active Substances	<0.2	0.5
Phenolic Substances as Phenol	Not Detectable ¹	0.002
Phosphates as PO ₄ (inorganic)	<0.2	0.2
Total Dissolved Solids	<500	1,000
Total Hardness as CaCO ₃	<120	See Section 8.3.2(2)
Organics as CCE + CAE ²	<0.05	0.2
Sulphate as SO ₄ [—]	<250	500
Sulphide as H ₂ S	Not Detectable	0.3
Uranyl Ion as UO ₂ [—]	<1.0	5.0
Zinc as Zn	<1.0	5.0

¹ "Not detectable" by the method described in the latest edition of "Standard Methods" (AWWA, APHA, WPCF) or by any other acceptable method approved by the control agency.

² Total of carbon chloroform and carbon alcohol extractibles.

³ Based on taste and odour considerations. Concentration greater than 0.05 mg/l may be objected to by the majority.

concentration of drinking water as close to the recommended optimum values as possible.

When fluoride is naturally present in water supply sources, the concentration of this chemical should not exceed 1.5 mg/1 F^- . Drinking water with a fluoride ion concentration greater than 1.5 mg/1 should be considered undesirable because of the possibility of the occurrence of enamel fluorosis in a small percentage of children so exposed for a long period of time. It is recommended that, where the fluoride ion concentration is greater than 1.5 mg/1 a dental health survey be instituted to study the possible incidence of enamel fluorosis and to determine whether the water should be defluoridated.

Sampling: Where fluoridation is practised to adjust the concentration of fluoride ion to the recommended optimum level, at least one sample of treated water per day should be collected and the concentration of fluoride ion measured by the "Standard Method" or other acceptable method **as approved by the control agency.**

Where the concentration of naturally present fluoride ion is less than 1.5 mg/1, the general sampling schedule recommended in Section 6 for other chemical analyses should be followed under ordinary circumstances.

- 6.5 **Other Chemicals:** The limits of other chemicals recommended in Table VIII should be regarded as *objectives* applicable to the treated water as supplied to the consumer.

7. Radiological Characteristics

- 7.1 **Sampling:** Under normal circumstances, analyses for gross radioactivity, or individual radionuclides (depending upon local conditions and use of radioactive substances), need be made only annually. All samples for radioactivity analyses should be composited over a three-month period. Where experience, analytical data, and other available evidence indicate that radioactive substances are consistently absent from a water supply system, or are below the *objective* limits, the frequency of examination for these substances may be reduced, **subject to approval by the control agency.**

If, however, there is sufficient reason to suspect the introduction, or natural presence, of radioactive substances, determinations for radioactivity should be made more frequently to ensure that the concentration levels are below the *acceptable* limits specified in Table IX. An exhaustive survey should be made to determine the source of pollution, and suitable corrective action should be taken immediately.

Where public supplies are derived from sources receiving continuous discharges of radioactive wastes, the sampling frequency

should be increased to at least two three-month composite samples per year (or any consecutive 52-week period), or as recommended by the federal or the provincial radiation protection agency. Such samples should be analyzed for the suspected radionuclide and gross radioactivity.

The burden of sampling and analyses for radioactivity may be alleviated in many cases by using data from acceptable sources, such as the Radiation Protection Division, Department of National Health and Welfare, Government of Canada, or the provincial radiation protection agency.

7.2 Limits:

TABLE IX*
DRINKING WATER STANDARDS
FOR RADIOACTIVITY

<i>Objective</i>	<i>Acceptable Limit</i>	<i>Maximum Permissible Limit</i>
1/10 of the ICRP (MPC) _w for 168-hour week.	1/3 of the ICRP (MPC) _w for 168-hour week.	The ICRP (MPC) _w for 168-hour week.

ICRP—International Commission on Radiological Protection.

(MPC)_w—Maximum Permissible Concentration in Water.

*Applicable to all radioactive substances (See Section 8.4) in raw as well as the treated water.

Water supplies may be considered as meeting the *objective* presented in Table IX if analysis shows that the gross radioactivity is **less than 10 picocuries per litre**. Radioactivities above this limit require further investigation to determine the nature of the activity and the desirability of systematic surveillance or other action.

8. *Criteria for Developing the 1968 Canadian Drinking Water Standards and Objectives*

8.1 **Physical Characteristics:** Inasmuch as “health” is conceived herein as including considerations of aesthetic satisfactions, and not merely the absence of disease or infirmity, it is recognized that drinking water should meet the aesthetic requirements of the consumer where circumstances permit. Therefore, drinking water should be free from objectionable levels of colour, odour, taste, temperature, and turbidity. These parameters *per se* are not *directly* linked with the health of man, in a physiological sense.

8.1.1 **Colour:** The indicated limits on colour in drinking water are developed primarily to meet aesthetic satisfaction, and secondarily to prevent possible staining of clothes, food,

and fixtures. Excessive colour may also indicate the presence of undesirable organic substances. Generally, when the colour of drinking water is below 5 True Colour Units, the water will not be objected to by the majority of the consumers since at these levels there will be no significant effects on either the appearance of water or its staining characteristics. When the colour value approaches the *acceptable* limit of 15 T.C.U., it may be desirable to investigate the cause and nature of such colour to determine the acceptability of the water supply.

- 8.1.2 **Odour and Taste:** Problems of odour and taste are very complex because the senses of smell and taste are intimately related, and their responses are often difficult to differentiate clearly. Since taste and odour are inseparable, limits on odour should also reflect the palatability of the finished water.

The effectiveness of water treatment processes in removing odours is highly variable depending on the nature of odour-producing substances. Often finished waters may have higher threshold odour values than *raw* waters, and the type of odours may also be quite different.

Currently, available methods for determining odour, in either cold or hot water, are subjective and they lack precision. Nevertheless, these are the only methods that are practicable, at the present time, in routine analyses for odour.

Odours at the indicated *objective* limit may not be objected to by the majority of the consumers. When the T.O.N. value approaches the *acceptable* limit of 4, it may be desirable to investigate the cause and nature of such odour.

- 8.1.3 **Temperature:** Drinking water should be cool so that it will be refreshing. It is recommended, therefore, that the temperature of water as supplied to the public should be less than 15°C. Organic growths in distribution lines, and odour-taste characteristics of water may be intensified at temperatures above approximately 15°C.
- 8.1.4 **Turbidity:** A limit on turbidity is recommended to promote clarity and appearance of the treated water. From an aesthetic viewpoint, turbidity above 1 JTU may be objected to by the majority of the consumers. Excessive turbidity may also interfere with disinfection processes. When the turbidity approaches the *acceptable* limit of 5 JTU, it may be necessary to improve the effectiveness of treatment processes.

Excessive turbidity in the *raw* water source indicates inordinate fouling by natural or man-made causes. Although highly turbid waters can be treated by a combination of flocculation, sedimentation, and filtration processes, large quantities of turbidity-causing substances impose a heavy load on treatment facilities and, when organic or soluble, may impart dissolved impurities to water with resultant deterioration of quality.

8.1.5 **Hydrogen Ion Concentration (pH):** Water in the pH range of 6.5 - 8.3 is acceptable provided other conditions are satisfactory. If the pH of water is outside this range, then an evaluation of the causes for either low or high pH should be made and assessed in terms of their effects on the treatment processes, and the potability of the water. At higher pH's there is a progressive decrease in the effectiveness (rate and per cent kill of organisms) of chlorine disinfection processes. The pH of water should also be evaluated in terms of its significance should problems of corrosion or incrustations occur in the system.

8.2 **Microbiological Characteristics:** The biological characteristics of water are distinguishable by the following effects that are significant from a water quality control viewpoint:

(a) Bacterial, viral, protozoal, and helminthic organisms capable of transmitting infections and diseases by the water route.

(b) Planktonic algae, actinomycetes, fungi, and other organisms capable of producing objectionable odours, tastes, colour, and turbidity.

(c) Organisms capable of producing toxic effects by the release of extracellular, metabolic end-products.

(d) Nuisance organisms which interfere with water treatment processes and operations.

These four types of effects may be caused by *primary* or *corollary* pollutants.

8.2.1 **Nuisance Organisms:** It is impracticable to place definite significance upon the concentration of planktonic organisms, except, perhaps, as it is related to water treatment processes (e.g. clogging of strainers and filters). Individual species of organisms differ widely in their abilities to produce objectionable odours, tastes, colour, turbidity, and toxic metabolites. For example, the presence of a single species of *Synura* (the brown, flagellate alga), in a relatively low concentration, may produce serious odour and taste problems in a water supply. On the other hand, larger numbers of certain other organisms can be con-

trolled relatively easily by the usual water treatment processes. It has been the general experience in many water treatment plants that objectionable odour, taste, colour or turbidity conditions develop when the total plankton count is greater than approximately 300 Areal Standard Units per millilitre.

It is difficult, however, to specify any quantitative limit on biological organisms which may cause problems of odour, taste, colour, turbidity, and toxic metabolites. These problems are covered indirectly by the limits on the physical characteristics of water presented in Table I.

8.2.2 Coliform and Pathogenic Organisms: The coliform group of organisms is defined as: "The coliform group includes all of the aerobic and facultative anaerobic, Gram-negative, non-sporeforming, rod-shaped bacilli which ferment lactose with gas formation within 48 hours at 35°C, or those that produce sheen colonies by the MF method." This definition is based on morphological and biochemical characteristics rather than in terms of kinds of bacteria.

The validity and reliability of the coliform organisms as indicators of enteric pollution are upheld, insofar as drinking water supplies are concerned, for the following reasons:

- (1) The absence of coliform bacteria is the best available evidence that a drinking water is bacteriologically safe;
- (2) The density of faecal coliforms is usually roughly proportional to the amount of enteric pollution present;
- (3) If pathogenic bacteria of intestinal origin are present, faecal and non-faecal coliform bacteria are also present, usually in much greater numbers;
- (4) Faecal and non-faecal coliforms are always present in the intestines of humans and most other warm-blooded animals, and are eliminated in large numbers in enteric wastes;
- (5) Coliforms are generally harmless to humans and can be determined quantitatively by routine laboratory procedures.

It is recognized, however, that there are some limitations to the validity of the coliform group as an indicator. Some of the members of the coliform group have a wide environmental distribution in addition to their occurrence in the intestines of homothermous animals; tests for coliforms are subject to interferences due to other kinds of bacteria.

Information on the sanitary significance of the various types of coliform organisms is incomplete at the present time. The present position in relation to *raw* water sources,

however, may be summarized as follows:

Faecal coliform organisms may be regarded as indicators of recent pollution by enteric wastes. No reliable, and routinely applicable, method is currently available for differentiating the faecal coliform organisms of human and animal origin. It is necessary, therefore, to consider *all* faecal coliform organisms as indicative of hazardous contamination.

In the absence of faecal coliform organisms the presence of the *Intermediate-Aerogenes-Cloacae* (IAC) group of organisms in untreated waters may be the result of relatively less recent faecal pollution, soil run-off water, or, infrequently, enteric pollution containing only the IAC group.

In general terms, the presence of faecal coliform organisms indicates recent and possibly hazardous pollution. The presence of the IAC group of organisms suggests less recent enteric pollution or reveals the existence of defects or inadequacies in water treatment or distribution. *It is emphasized, however, that the substitution of a faecal coliform test for total coliforms in monitoring and evaluating drinking water quality should not be permitted.*

The presence of any type of coliform organism in treated drinking water suggests either inadequate treatment and disinfection, or access of undesirable materials to the water after treatment or inadequate chlorine residual in the distribution system. The presence of any type of coliform organisms in treated water, therefore, necessitates definitive action for their elimination.

The coliform group is considered a reliable and relatively rapidly detectable, indicator of the adequacy of treatment. The coliform group is preferred to faecal organisms as an indicator of contamination of **drinking water supply systems**, and indirectly as an indication of the degree of protection provided. It cannot be determined, however, at the present time whether these considerations can be extended to include viruses and pathogenic organisms other than bacteria that may be water-borne.

- 8.3 **Chemical Characteristics:** The chemical quality of *raw* water sources and treated water are of major significance for several reasons. Various chemicals, beyond certain concentration levels have been demonstrated to cause public health hazards, interference with water treatment processes, staining of fixtures and plumbing, alteration of the physical characteristics of water to

objectionable levels, and other interference with the intended domestic uses of the finished water. Only those dissolved chemicals that are physiologically harmful and economically damaging, and those that cause aesthetically objectionable effects are considered in proposing these limits.

In general, the *maximum permissible* (or "grounds for rejection") limits are based on long-term adverse effects on human health. Substances, for which *maximum permissible* limits are specified, may give rise to actual danger to the health of man, if present in drinking water supplies at concentrations above the indicated levels. In arriving at these specific limits, the total environmental exposure of man to a specified toxicant has been taken into consideration. These limits are set at the lowest practical level in order to minimize the amount of a toxicant contributed by water, particularly when other sources such as food, milk, or air are known to represent the major sources of exposure of man.

In general, the *acceptable* limits are based on factors which render a supply less desirable for the intended domestic uses. These considerations relate, in the majority of the cases, to chemicals which impart objectionable colour, odour, or taste to water, or render it aesthetically or economically inferior in quality, or are toxic to fish and domestic plants.

Objectives are recommended as quality goals for long-range improvements.

8.3.1 **Toxic Chemicals:** The criteria used in designating the *maximum permissible* limits for arsenic, barium, cadmium, chromium, cyanide, lead, and selenium (Table VI) are derived from the 1962 United States Public Health Service Drinking Water Standards. The limits on boron and nitrate plus nitrite are included under "toxic chemicals" for the following reasons:

(1) **Boron:** Although boron is known to be rapidly absorbed in the human intestine and excreted in urine, the ingestion of large amounts of this chemical may affect the central nervous system. The protracted ingestion of boron may result in a clinical syndrome referred to as "borism". The *maximum permissible* limit on boron of 5.0 mg/l is set, therefore, on the basis of long-term effect on human health.

(2) **Nitrates and Nitrites:** Nitrates are known to produce irritation of the mucous membrane of the stomach, and diuresis (increased excretion of urine) accompanied by irritation of the mucous membrane of the urinary bladder. However, it is not possible, at the present time, to specify a safe concentration limit for nitrate on this basis.

The indicated limit on nitrate plus nitrite of 10 mg/l as nitrogen is based on the relationship established between this chemical and the possible occurrence of infantile methaemoglobinemia.

Infantile methaemoglobinemia, a disease characterized by specific blood changes and cyanosis, has been related to high nitrate-nitrogen content of water, particularly of ground water sources, used in preparing infant formula. Most reported cases of this disease have been associated with the use of water containing 45 mg/l or more of nitrates as NO_3 in waters which were exclusively of underground sources. No cases of this disease have been reported in Canada and the United States of America in areas where the drinking water consistently contained less than 10 mg/l as $\text{NO}_3 + \text{NO}_2$ as N.

8.3.2 **Other Chemicals:** The following criteria have been used in arriving at the specific limits on other chemical characteristics.

(1) **Alkalinity:** A limit on alkalinity may be necessary to ensure that (a) it is sufficient to enable optimum floc formation during coagulation processes in water treatment, (b) it is not high enough to cause gastrointestinal irritation or discomfort, and (c) it affords proper chemical balance of water so that the water is neither corrosive nor incrusting. Such an evaluation can be based on the relative amounts of carbonate, bicarbonate, and hydroxyl ions, total dissolved solids, calcium, and the pH of water.

Generally, in water analysis, alkalinity is expressed in terms of the equivalent amount of calcium carbonate. An under-saturation with respect to CaCO_3 may promote reactions causing iron pickup and the consequent development of "red water". An over-saturation with respect to CaCO_3 may result in incrustations on utensils, service pipes, and water heaters. The point of chemical stability, with respect to alkalinity, may be highly variable in different waters, and, from time to time, in the same water.

Alkalinity in the range of 30 - 500 mg/l as CaCO_3 is generally acceptable, but it does not guarantee that problems due to this characteristic, in this range, will not occur. It is certainly necessary, however, that each water should be evaluated on its own merit, with respect to alkalinity, taking into consideration all factors influencing this characteristic of water.

(2) **Hardness:** There are no reported instances where substances causing or contributing to hardness are directly

implicated as causing health problems, although some investigators have demonstrated an *inverse* statistical correlation between water hardness (as a characteristic) and certain types of cardiovascular diseases. On the other hand, the major detrimental effect of hardness is economic. An evaluation of water quality, with respect to hardness, should take into consideration soap consumption, incrustations on service pipes, cooling coils, water heaters, and kitchen utensils, and consumer sensitivity, adaptability, and acceptance.

Hardness is usually expressed in terms of the equivalent quantity of calcium carbonate (CaCO_3). The quality of drinking water with respect to hardness may be classified as presented in Table X.

TABLE X
CLASSIFICATION OF DRINKING WATER
QUALITY BASED ON HARDNESS

Quality Classification	mg/1 CaCO_3	grains (CaCO_3)/ imp. gal.	grains (CaCO_3)/ U.S. gal.
Very Good	<80	<5.6	<4.7
Good	81-120	5.6-8.4	4.7-7.0
Fair	121-180	8.4-12.6	7.0-10.5
Poor	>180	>12.6	>10.5

If the hardness of water exceeds 500 mg/1 as CaCO_3 , the water may be unsuitable for domestic or industrial uses. From a consumer acceptability point of view, it is desirable to reduce hardness to a level below 120 mg/1 as CaCO_3 .

(3) **Corrosion and Incrustation:** These characteristics of water are determined by a complex interaction of such factors as temperature, pH, alkalinity, sodium, magnesium, calcium, organic materials, carbon dioxide, dissolved oxygen, chloride, sulphates, phosphates, total dissolved solids, and velocity of flow. Corrosion or incrustation may cause considerable economic damage to the water supply system. It is important, therefore, that the effects of these characteristics of water on the system be evaluated.

It is recommended by the A.W.W.A. Task Force on Water Quality Goals (1968) that the 90-day incrustation rate on stainless steel, using "coupon insertions", should not exceed 0.05 mg/sq cm, and the 90-day loss by cor-

rosion on galvanized iron should not exceed 5.00 mg/sq cm.

(4) **Ammonia:** The concentration of ammonia should be limited for two major reasons: (1) it can react readily with chlorine to form compounds with markedly less disinfecting efficiencies than the HOCl molecular or even OCl ionic forms of free chlorine; (2) it may promote the growth of organisms, and corrosion in distribution lines.

(5) **Calcium:** Although calcium is essential for the human body, the nutritional value of this element in drinking water has not yet been determined. Excessive calcium in drinking water may be a factor predisposing to the formation of concretions in the body, in organs such as kidney or urinary bladder, and to irritation of urinary passages resulting in difficulty in passing urine.

However, so far as can be determined at the present time, calcium limits are desirable for domestic water supplies not because of a hazard to health, but because calcium may be detrimental to other domestic uses such as washing, bathing, and laundering, and because it tends to form incrustations on cooling coils, utensils, water heaters, and other fixtures.

(6) **Chloride:** A limit is proposed primarily on taste considerations, and possible effects on other household uses, such as coffee brewing.

(7) **Copper:** Copper in small amounts does not constitute a health hazard. On the other hand, copper is an essential and beneficial element in human metabolism. It is well known that a deficiency in copper results in nutritional anaemia in infants.

Copper, however, will impart undesirable taste to water, but the threshold for taste perception of this element varies from 1-5 mg/l as Cu. Large doses of copper have been known to produce emesis and prolonged ingestion may result in liver damage. The suggested limits, however, are based on considerations of taste and staining characteristics of copper in water.

(8) **Iron:** Iron is a highly objectionable element in water supplies for domestic uses. One of the significant effects of iron is that it imparts a brownish colour to laundered goods. Iron also stains plumbing fixtures and causes a deposition of a slimy coat. Excessive iron may promote the growth of filamentous iron bacteria in water mains and service pipes. Under certain chemical conditions, excessive iron may be precipitated in water. The taste of water and

beverages may also be appreciably affected by iron. It is generally believed that the intake of iron through drinking water is only of secondary importance insofar as the nutritional requirement of this element is concerned, because the 1 - 2 mg/day iron requirement can be obtained from a reasonably balanced diet. The suggested *acceptable limit* of 0.3 mg/1 is based on considerations of effects on household uses, and the *objective* limit of 0.05 mg/1 on taste considerations.

(9) **Magnesium:** This element should be considered along with hardness, and sulphate. In the presence of low concentrations of sulphates, magnesium may be acceptable up to a level of 150 mg/1 as Mg provided the taste and hardness of the water are not objectionable.

(10) **Manganese:** The two important reasons, namely, (a) aesthetic and economic damage, and (b) possible physiologic effect, as discussed in the 1962 U.S.P.H.S. Drinking Water Standards, are upheld in this document in proposing the *acceptable* limit for manganese of 0.05 mg/1 as Mn. The *objective* of 0.01 mg/1 as Mn is recommended on the basis of possible staining effects, particularly in conjunction with iron.

(11) **Methylene Blue Active Substances (MBAS):** Although there have been numerous publications on synthetic detergents and water pollution, since 1962, information on the physiological role of these substances in water, from a public health standpoint, is incomplete.

There is a need, however, to set a limit on the methylene blue active substances in order to prevent the possible occurrence of the following problems: foaming, excessive turbidity, interference with water coagulation-flocculation and sand filtration in water treatment processes, and odour-tastes. The effectiveness of chlorine disinfection may be reduced if the concentration of MBAS is over 4.0 mg/1 as ABS-equivalent. Concentrations of MBAS above 0.5 mg/1 as ABS-equivalent are also indicative of other wastewater pollution.

(12) **Organics (Carbon Chloroform and Alcohol Extractibles) (CCE + CAE):** It is relatively difficult to detect, identify, and quantify organic substances of public health significance in water supplies. The test procedures are complex, expensive, and not practicable in routine examinations. The CCE and CAE methods are technically practical procedures which will afford a large measure of protection against the presence of undetected toxic

materials in the treated water. However, it is recognized that not all organic pollutants in water are adsorbed on activated carbon with equal efficiency, and that there is a low yield of certain organic chemicals when eluted after adsorption.

It is desirable that the water as delivered to the consumer contains no organic residues which may have a toxigenic potential even at extremely low quantities (in the microgram-per-litre range). Also, residual organic matter in the treated water clearly represents man-made or natural pollutants which have not been removed in water treatment, or pollutants such as lubricants which may have been introduced inadvertently at the water treatment plant.

In view of the general inability to clearly define the constituents of organic residues, and their toxicological nature, it is recommended that these substances be limited to 0.20 mg/l as the *acceptable* level. Drinking water containing over 0.20 mg/l of CCE + CAE substances represent an undesirable dosage of ill-defined chemicals to the consumer.

(13) **Phenolic Substances:** Phenolic substances are known to cause physiologic effects only in very high concentrations. The long-term effect of continuous ingestion of low concentrations (in the microgram-per-litre range) of these substances through drinking water is not determined at the present time. A limit on these substances, however, is set primarily to prevent the occurrence of undesirable tastes and odours, particularly in chlorinated water. The threshold concentrations for taste or odour produced by these substances range from as low as 0.01 mg/l to as high as 60 mg/l as phenol, and from 0.00001 to 0.02 mg/l as phenol in chlorinated water. The suggested *acceptable* limit of 0.002 mg/l as phenol is based primarily on taste-odour considerations.

(14) **Phosphorus:** The role of inorganic phosphate in water is rather complex and it is difficult to establish judicious criteria for limiting concentrations of this substance in drinking water. It is recognized, however, that phosphates, in general, may stimulate the growth of photosynthetic organisms if other essential growth stimulants are present. Phosphates may also interfere with water coagulation through the formation of complex phosphate compounds, even at concentrations as low as 0.1 mg/l as PO_4 . It is necessary to limit the phosphate concentration in *raw* water sources, particularly in reservoirs, to prevent

excessive growth of photosynthetic organisms and the resultant problems of odour and tastes and other detrimental effects. It appears that even a concentration of 0.2 mg/l as PO_4 may be high under some conditions.

(15) **Sulphates:** The direct physiological effects of sulphates on humans is catharsis (purgation of the alimentary canal). It is known that many communities in Canada have been using waters containing sulphates considerably in excess of the generally accepted limit of 250 mg/l as SO_4^{--} . Concentrations of sulphates up to 500 mg/l as SO_4^{--} have been, and are currently being, tolerated by some communities without any reported gastrointestinal irritation or discomfort. However, it is recognized that high concentrations of sulphates may contribute to objectionable taste in water. Therefore, the *acceptable* limit is set at 500 mg/l as SO_4^{--} . Waters with sulphate concentration above 500 mg/l as SO_4^{--} may not be usable for drinking purpose since gastrointestinal irritation and catharsis, and objectionable taste may occur.

(16) **Total Dissolved Solids (Filterable Residue):** In general, concentrations of total dissolved solids in excess of 500 mg/l in drinking water may not be acceptable on grounds of undesirable taste, and, perhaps, also laxative effects. It is recognized, however, that many communities in Canada and elsewhere have been, and are currently using drinking water, particularly of ground water sources, containing TDS concentrations in excess of 500 mg/l. Waters with a TDS concentration over 1,000 mg/l are of very poor quality for drinking purpose. Such waters may also be of unusual chemical composition and may contain one or more toxic chemicals in concentrations greater than *acceptable* limits. The total dissolved solids content of a drinking water, therefore, should be evaluated in terms of the individual dissolved constituents which may have health, aesthetic and economic significance. The basic criterion used in specifying the indicated limits, however, is palatability rather than possible health or economic effects.

(17) **Uranyl Ion:** Uranyl ion is suspected as being capable of producing damage to kidneys. This chemical may also produce objectionable taste and colour in water. The threshold level for taste is approximately 10 mg/l as UO_2 which is much less than the safe limit of ingestion from a physiological viewpoint. The *maximum permissible limit*

of 5.0 mg/1 as UO_2 is based, however, on colour and taste considerations.

(18) **Zinc:** This element does not cause serious effects on health, but produces undesirable aesthetic effects. Excessive zinc salts may impart milky appearance and a metallic taste to water. The proposed *acceptable* limit of 5.0 mg/1 as Zn is based on aesthetic effect and to prevent possible addition of lead and cadmium which are some of the contaminants of zinc.

8.3.3 Biocides: The term “biocides” is used to include all organic chemical agents employed for the control of pests, disease vectors and nuisance organisms on land and in water. Three major groups of biocides are important in water quality evaluations: (a) chlorinated hydrocarbons and their derivatives, (b) herbicides, aquatic weedicides, fungicides, algicides, and similar compounds, and (c) the cholinesterase-inhibiting compounds which include the organophosphorus chemicals and carbamates.

The important justification for setting *maximum permissible limits* on biocides are: (a) toxicological and health effects on man on the basis of long-term exposure, and (b) taste and odour effects on water. These limits are also based on possible cumulative dosage due to biological concentration of biocides. In view of the fact that conventional water treatment processes such as flocculation-coagulation, sedimentation, filtration, and disinfection are not appreciably effective in the removal of dissolved biocides, these limits should be applicable to the *raw* water source as well as the treated water as supplied to the community. *It should be noted that these limits are not based on possible synergistic or antagonistic effects of two or more biocides occurring concurrently in water.* Under emergency conditions, the question of *maximum permissible* limits of biocides for short-term exposure (a few days to a few weeks) should be referred to expert toxicologists or the control agency.

The toxicity of chlorinated hydrocarbon biocides to fish is generally many times greater than to humans, and the toxic limit for fish is several orders of magnitude above concentrations normally occurring in surface streams. Therefore, fish survival may be used as the “safety test”. There is now no other rapid method of determining the safety of a water for human consumption. Chlorinated hydrocarbon compounds in water tend to persist in the environment in their original form over long periods. They may thus cause direct health effects or indirect effects due

to biological concentration in man's food chain which may contribute to the daily intake by man of the otherwise low level dosage.

The proposed *maximum permissible* limits of chlorinated hydrocarbon biocides (in Table VII) are below known fish toxicity levels taking also into account the tendency for fish and fish-food organisms to concentrate these materials in their bodies, and, in the cases of aldrin, heptachlor, chlordane, lindane, and parathion, the possible occurrence of objectionable or noticeable odours in water.

Organo-phosphorus and carbamate compounds are generally less toxic to fish and mammals than many chlorinated hydrocarbon biocides. But, nearly all organo-phosphorus compounds and the cholinergic carbamates are known to have high acute toxicity to mammals, and some have even higher toxicity to fish. The ingestion of small quantities of these compounds over long, continuous periods of time causes damage to mammalian central nervous system. However, many organo-phosphorus compounds hydrolyze rapidly in the environment to harmless or less harmful products. The only relatively rapid method presently available is the cholinesterase test. Therefore, the limit on organo-phosphorus and carbamate compounds is expressed as parathion equivalents in cholinesterase inhibition test.

It is desirable that drinking water be free of biocides. Every effort should be made to exclude biocide pollution of raw water sources. It is emphasized that the specification of *maximum permissible* limits of biocides in this document should not be interpreted as a permit to allow the degradation of drinking water supplies to the indicated limits.

- 8.4 **Radiological Characteristics:** Individuals may be exposed to ionizing radiation from sources external to the body and/or from sources taken into the body. In assessing the significance to health, it is necessary to take into account the total radiation dose derived from external and internal sources.

For radiation sources taken into the body, the modes of entry include inhalation and ingestion (in food and/or water). For the purposes of this guide, it is assumed that water is the only significant source of radiation exposure. When this is not the case, special care must be taken in the use of the limits specified in Table IX, and it will probably be necessary to consult with radiation protection specialists.

Radiation exposure may also take place over a short interval of time (acute exposure), or it may occur relatively constantly

over long periods of time (chronic exposure). When an accident occurs, and radioactive contamination exists for a short period of time, it is not unrealistic to apply different "standards" as compared with the situation involving low-level chronic exposure. The significant fact is the accumulated radiation dose and therefore much higher dose rates can be tolerated if the time interval is short.

Various national and international bodies have studied these problems in great detail. One of the most prominent organizations is the International Commission on Radiological Protection (ICRP), and its recommendations have been adopted by many other agencies. ICRP Publication 9 contains the latest recommendations concerning the Maximum Permissible Doses for the whole body and selected organs under various conditions of occupational exposure. ICRP Publications 2 and 6 contain extensive tables of Maximum Permissible Concentrations in air and in water for many radionuclides. Since these "standards" are intended for use in planning radiation work, concentration figures are given in terms of a 40-hour exposure week (a normal working week), but figures are also given for a 168-hour week (constant exposure). The figures are based on calculations which show that for the "standard man", regular occupational exposure at the stated Maximum Permissible Concentrations in either air or water would not lead to the accumulation in his body of sufficient radioactivity to deliver more than the ICRP's Maximum Permissible Annual Dose to the body or selected organ. For this purpose, the "standard man" is assumed to breathe air and consume water at specified standard rates. The biological handling of each radionuclide is also assumed to be the same for all radiation workers, and the calculations are made separately for each radionuclide.

In considering the question of exposure of members of the public, the ICRP has recognized that the setting of dose limits is a theoretical concept since it is not practicable to monitor such individuals. The value of such limits is in providing guidance for the design and operation of radiation sources so that it is unlikely that individuals in the public will receive more than a specified dose. The effectiveness of compliance is through sampling procedures in the environment and statistical calculations. The ICRP recommends that the Annual Dose Limits for members of the public be one-tenth of the corresponding annual occupational Maximum Permissible Doses. This implies that the Maximum Permissible Concentration figures for air and water should also be multiplied by 1/10.

Thus, for drinking water supplies, it is possible to develop guidance with respect to radioactivity concentrations. Following the general pattern adopted for this report, standards for radioactivity are expressed in terms of *objective*, *acceptable*, and *maximum permissible* limits (Table IX).

APPENDICES

APPENDIX I

Glossary

1. **ACTINOMYCETES** — A group of branching filamentous bacteria reproducing by terminal spores. They are common in the soil. These bacteria are known to cause offensive taste and odour in water.
2. **ALGA (Pl. ALGAE)** — Comparatively simple plants containing photosynthetic pigments such as chlorophyll. A majority of algae are aquatic and many are microscopic in size.
3. **ANTAGONIST** — An agent, such as a chemical, which tends to nullify the action or effect of another agent or force when both are present concurrently in a medium.
4. **AREAL STANDARD UNIT** — An area of 400 square microns on a microscopic slide or counting chamber, used as a unit in designating the concentration of microorganisms, such as algae, in water. One micron = 1×10^{-3} millimetre.
5. **BIOCIDE** — An organic chemical agent used for the destruction of living organisms such as pests, nuisance organisms, and weeds, aquatic or terrestrial (e.g. pesticide, algicide, weedicide, fungicide).
6. **BORISM** — Poisoning by a boron compound.
7. **CAE** — Carbon Alcohol Extractibles; substances extracted by alcohol, from an activated carbon column ("filter") through which unchlorinated water has been passed.
8. **CATHARSIS** — Purgation of the alimentary canal.
9. **CCE** — Carbon Chloroform Extractibles; substances extracted by chloroform, from an activated carbon column ("filter") through which unchlorinated water has been passed.
10. **CHLORINATION** — The application of a chlorine compound to water for the purpose of disinfection, and frequently, also, for accomplishing other biological or chemical results in the treatment of water.
11. **CHOLINERGIC** — Stimulated, activated, or transmitted by acetylcholine; the term is applied to those nerve fibres which liberate acetylcholine at a synapse when a nerve impulse passes, i.e. parasympathetic nerve endings.
12. **CHOLINESTERASE** — An esterase (enzyme) present in all body tissues which hydrolyzes acetylcholine into choline and acetic acid.
13. **COAGULATION** — A water treatment process comprising a series of chemical and mechanical operations involving the addition of chemicals (coagulants) to water, their mixing and uniform distribution through the water and the building up of a readily settleable floc, usually by prolonged agitation of the water. This process may be distinguished into two separate phases, "mixing" and "flocculation".
14. **COMPLETE TREATMENT** — A system of water treatment processes including coagulation (mixing and flocculation), sedimentation (settling or clarification), filtration, and disinfection or, as used in this document, a combination or modification of these processes but always including disinfection.
15. **CONTAMINATION** — The introduction into otherwise potable water of toxic materials, pathogenic or undesirable microorganisms, and other deleterious substances which make the water unfit for use; a specific type of "pollution".
16. **CONTROL AGENCY** — A governmental health or water quality and pollution control agency vested with the responsibility of assessing the safety and approving a drinking water supply.

17. **COROLLARY POLLUTANT** — Any chemical substance or biological organism that is indigenous to the waterbody (e.g. naturally occurring chemicals, algae, fungi, invertebrate larvae, etc.).
18. **COUPON INSERTION (COUPON TEST METHOD)** — A method for the quantitative measurement of corrosion and scaling characteristics of water on metal coupons in the absence of heat transfer. Carefully prepared metal coupons are installed in contact with flowing water for a measured length of time, and, after removal, the coupons are examined for depth, distribution, weight, and character of foreign matter on coupons, and the corrosion characteristics of the water by the difference in weight.
19. **CULINARY** — Pertaining to a kitchen or cookery.
20. **CYANOSIS** — Blueness of the skin and the white of the eye, due to insufficient oxygenation of the blood resulting in the formation of methaemoglobin.
21. **DISINFECTION** — A process of destroying microorganisms and vegetative cells occurring in water by the application of a chemical agent (disinfectant) such as a chlorine compound (see chlorination).
22. **DIURESIS** — Increased secretion of urine.
23. **EMESIS (EMESIA)** — Vomiting or an act of vomiting.
24. **ENTERIC** — Pertaining to the intestines.
25. **ENTEROVIRUS** — Virus of intestinal origin; as used in this document, this term refers to a virus discharged from the intestines of warm-blooded animals including man.
26. **FAECAL COLIFORM ORGANISM** — A member of the group of coliform organisms, and of faecal origin (i.e. from the intestines of warm-blooded animals including man).
27. **FLOCCULATION** — A phase of the coagulation process, involving agitation of the water at lower velocities than for "mixing", for a measured length of time during which the very small particles grow, coalesce, and agglomerate into well-defined hydrated flocs of sufficient size to settle readily (see Coagulation).
28. **FLUORIDATION** — The controlled adjustment of the fluoride ion concentration of drinking water to a selected concentration.
29. **FUNGUS (P1. FUNGI)** — A group of organisms without chlorophyll or other photo- or chemo-synthetic pigments, obtaining nutrients from preformed organic matter by absorption (i.e. "heterotrophic"); unicellular or filamentous organisms; some are parasitic in living tissues and may produce pathogenic conditions; others may cause odour and taste in water, and may cause nuisance conditions in sewers and watercourses.
30. **HEALTH** — A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity; it includes satisfaction of the aesthetic aspirations of man.
31. **HEALTH AGENCY** — A governmental department of health or a health unit.
32. **HOMOTHERMOUS** — Maintaining a uniform bodily temperature independent of the environmental temperature; birds and mammals (including man) are homothermous animals.
33. **IAC** — Intermediate-Aerogenes-Cloacae group of bacteria; may be found in faecal discharges, but usually in smaller numbers than *Escherichia coli*; also commonly present in soil and in water polluted sometime in the past; survive longer in water than do faecal coliform organisms; tend to be somewhat more resistant to chlorination than *E. coli* or the commonly occurring bacterial intestinal pathogens.
34. **ICRP** — International Commission on Radiological Protection.
35. **MBAS** — Methylene Blue Active Substances; anionic surface-active agents (synthetic detergents) which form a blue-coloured salt upon reaction with methylene blue.

36. **METABOLIC PROCESS** — The “building up” (anabolic) and the “tearing down” (Katabolic) biochemical processes of living cells.
37. **METABOLITE** — Any substance produced by a metabolic process of living cells.
38. **METHAEMOGLOBINEMIA** — A disease caused by the presence of methaemoglobin in the blood. Methaemoglobin is the modified oxyhaemoglobin or an oxidized heme containing ferric iron combined with the normal globin.
39. **MF METHOD** — Membrane Filter Method.
40. **MICRON** — A unit of linear measurement, often used for describing the dimensions of a microorganism or microscopic particle. One micron is the equivalent of one one-thousandth of a millimetre (1×10^{-3} mm or 0.03937×10^{-3} inch).
41. **MICROORGANISM** — Any minute plant or animal organism invisible or barely visible to the unaided eye (e.g. bacteria, viruses, algae, etc.).
42. **MPC_w** — Maximum Permissible Concentration in water.
43. **MPN METHOD** — Most Probable Number Method of quantitative analysis of coliform organisms (Multiple tube dilution fermentation method).
44. **NOT DETECTABLE** — Below limit of detectability by a specified method of analysis.
45. **PATHOGENIC (PATHOGENETIC)** — Giving origin to or resulting in disease or morbid symptoms.
46. **PHOTOSYNTHESIS** — A biochemical process by which an organism manufactures sugar or other carbohydrates from inorganic raw materials with the aid of light and pigments such as chlorophyll. Organisms possessing the ability to carry on photosynthesis are termed “photosynthetic” organisms.
47. **PICOCURIE** — A synonym for micromicrocurie; a subdivision of the unit Curie which expresses the rate of disintegration of a radionuclide, in which 3.7×10^{10} atoms disintegrate per second. One picocurie or micromicrocurie is the equivalent of 1×10^{-12} Curie.
48. **POLLUTANT** — A substance, biological, inorganic, organic or radioactive which brings about a condition of pollution.
49. **POLLUTION (Water)** — Anything causing or inducing objectionable conditions in any watercourse and affecting adversely the environment (ecology) and use or uses to which the water thereof may be put.
50. **POTABLE WATER** — Water which is drinkable and usable for culinary purposes, as a result of being free of pathogenic organisms (or their indicators), toxic substances, objectionable taste, odour, and colour, and other undesirable physical, chemical, and biological characteristics.
51. **PRIMARY POLLUTANT** — Any chemical substance or biological organism that is added directly or indirectly to water as a result of human activities within the watershed, (e.g. toxic chemicals, enteric bacteria, enteroviruses, etc.).
52. **RAW WATER** — Surface or underground water which is available as a source of drinking water supply but which has not been treated or “purified”.
53. **RADIOACTIVE** — Capable of emitting radioactivity, the spontaneous nuclear disintegration with emission of corpuscular or electromagnetic radiation or both.
54. **RADIONUCLIDE** — A radioactive atomic species characterized by the constitution of its nucleus, specifically by the number of protons and neutrons.
55. **RESERVOIR** — A basin, lake, pond, tank, or impoundment which is used for the storage of water to be supplied. It may be either naturally or artificially created by the building of a dam or retaining wall.
56. **RICKETTSIA (Pl. -e)** — Microscopic organism, having close resemblance to the Gram-negative bacteria, reproducing only in living cells, and capable of causing disease in animals and man. Human rickettsiae include Rocky Mountain Spotted Fever, Q-Fever, etc.

- 57. **SANITARY SURVEY** — A survey and analysis of the physical environment for the purpose of identifying existing and potential sources of health hazards and environmental contamination.
- 58. **SEDIMENTATION** — A water treatment process involving the settling out of the impurities, coagulated or otherwise.
- 59. **STANDARD** — A fixed or definitive requirement.
- 60. **STANDARD METHOD** — A method as outlined in the current edition of "Standard Methods for the Examination of Water and Wastewater", jointly published by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation.
- 61. **SURFACE WATER** — Water which rests or flows upon the surface of the earth, in contrast to "ground water".
- 62. **SYNERGIST** — An agent, such as a chemical, which tends to enhance the action of another agent or force when both are present concurrently in a medium.
- 63. **THRESHOLD ODOUR NUMBER** — A numerical figure designating the intensity of odour in a water as determined by its perception in a series of dilutions with "odour-free" water. It is calculated from the amount of the water sample in the most diluted portion giving perceptible odour, with the straight undiluted water being designated as having a threshold odour number (T.O.N.) of 1.
- 64. **TOXIC** — Pertaining to, due to, or of the nature of, a poison.
- 65. **TOXICITY** — The quality of being poisonous, especially the degree of virulence of a poison.
- 66. **TRUE COLOUR** — Colour attributable to substances in solution after the suspensoids have been removed by centrifugation (not by filtration).
- 67. **TRUE COLOUR UNIT** — A unit of colour equivalent to the colour produced by 1.0 mg/1 of chloroplatinate ion by the Platinum-Cobalt Method.

APPENDIX II

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